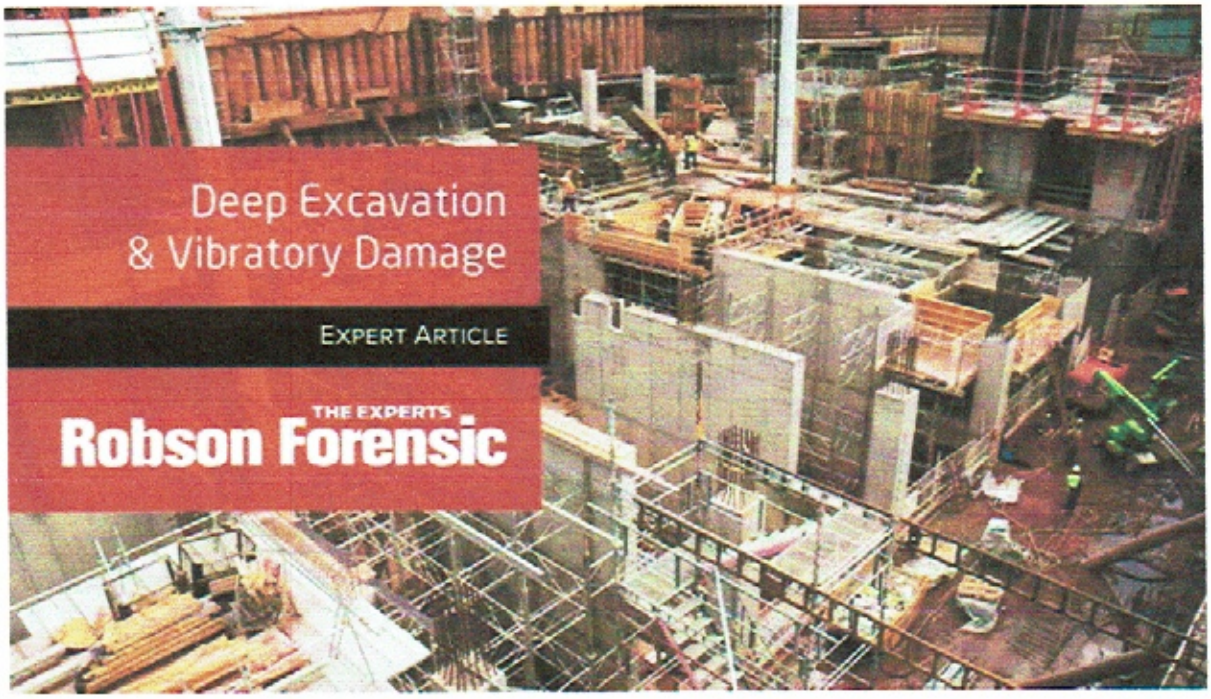
**Structural Damage from Adjacent Construction Projects – Expert Article**

Construction projects in urban and other congested environments frequently require deep excavations and/or the use of heavy vibrating equipment in close proximity to existing structures. These activities require careful planning and engineering in order to prevent damage to nearby buildings and structures.

In this article, structural engineer, Anthony Volonnino discusses the issues relevant to urban construction and some of the precautionary steps that engineers utilize to prevent damage to adjacent structures.




**DEEP EXCAVATION & VIBRATORY DAMAGE IN URBAN & CONGESTED AREAS**

There are numerous field conditions where construction activities in an urban setting can potentially damage neighboring structures. Deep excavation and/or construction related vibrations are primary culprits. Careful planning and engineering, pre-construction surveys, vibration monitoring, neighboring building movement monitoring, project coordination with neighboring properties, and overall due diligence all play a vital role in the successful completion of a new foundation system within an urban setting.

At Robson Forensic, our Civil/Structural Engineering experts regularly investigate claims involving collapses, damage, construction disputes, and personal injury related to demolition and construction activities at adjoining properties.

This article will cover two separate topics addressing construction means and methods which have the potential for causing damage to adjacent properties. The first is a commonly used method for

accomplishing deep pit excavations utilizing soldier pile walls with tiebacks. The second topic is that of vibration in construction.

**Deep Excavation in Urban Settings**

New large scale mid-rise and high-rise buildings in urban neighborhoods often require foundation structures 1 to 5 stories deep to accommodate underground parking decks and building mechanical systems. These new foundation systems are often much deeper than the foundations of previous structures as well as those of neighboring properties. As a result, construction activities require the excavation of deep pits, often with vertical faces. Damage to adjacent properties can result throughout this process from inadequately shored excavation walls, or from vibrations due to demolition, excavation, or pile driving activities.

Since most excavations in an urban setting occur on or near the property lines and flattened slopes (less than 45 degrees of vertical) are typically incompatible with design requirements, many applications require a temporary reinforced wall be constructed to retain soil and buildings on the neighboring lots. Construction in these circumstances requires a number of precautions to minimize or prevent damage to adjacent properties. These precautions should include:

- Preconstruction surveys which include photographs, videos, and documentation
- Coordination and permission with the adjacent property owners to install tiebacks below their foundations
- Careful planning and sequencing of the construction
- Borings and a geotechnical report
- A determination of water table and underground hydrology
- Dewatering and monitoring of dewatering
- Underground utility stakeouts
- Frequent periodic monitoring and surveys of adjoining buildings during construction
- Frequent vibration monitoring
- Engineered shoring plans which consider:
    - Surcharge loads from adjacent structures, soil stockpiles or equipment
    - Allowable/anticipated movement/serviceability of temporary wall systems
    - Geotechnical assumptions from a geotechnical report
    - Water table and dewatering

- Temporary and permanent support of neighboring structures such as underpinning
- Utilities
- Local, state and federal building code compliancy
- Vibration risk assessment
- Seismic/earthquake risk assessment

Even with implementation of the above precautions, it is still possible that destabilization of the retained earth wall may occur due to unforeseen conditions (i.e. unstable pockets of soil, perched water tables, or unanticipated foundation conditions). If this occurs, a skilled contractor/owner should identify and proactively mitigate the issues to prevent further damage caused by movement and/or consolidation of the soil of the neighboring properties.

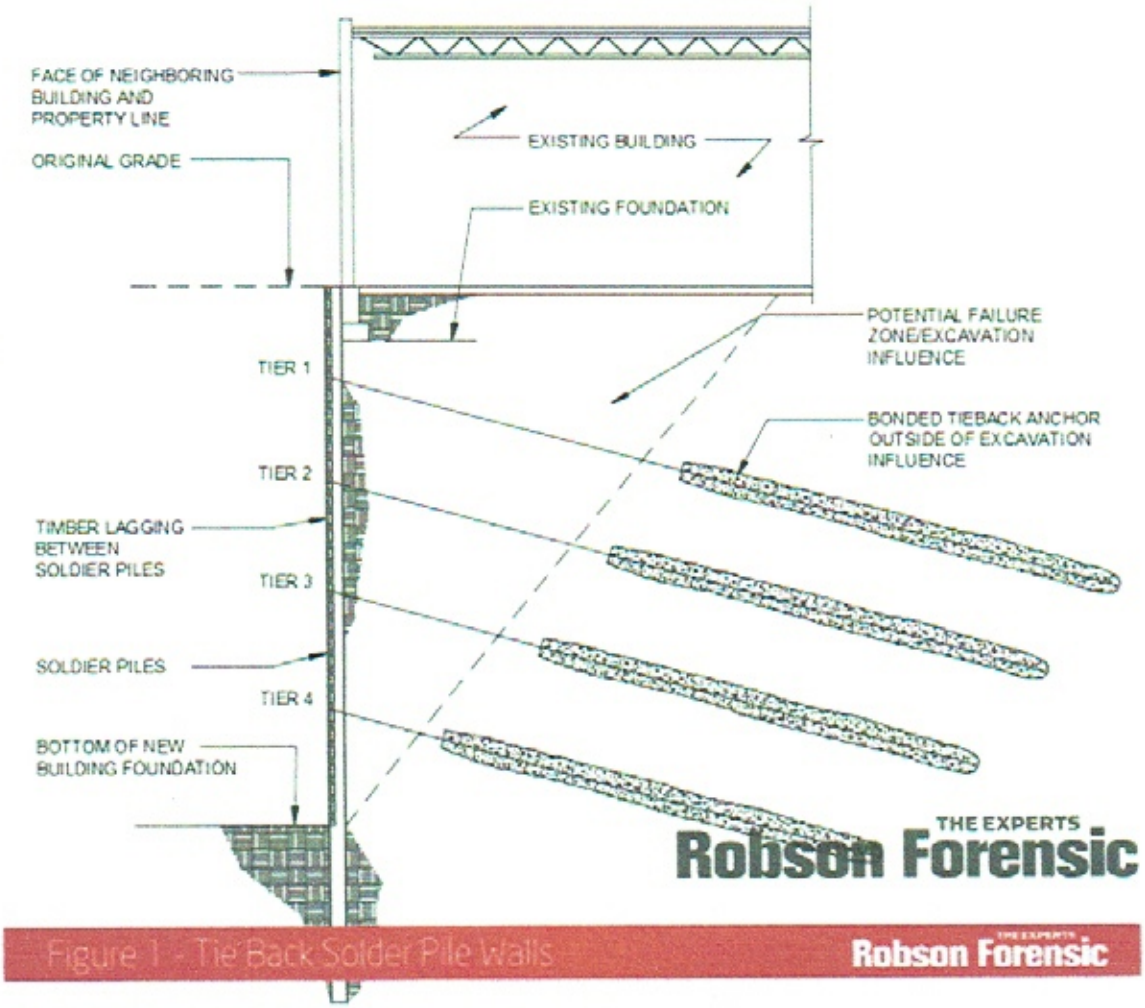


Figure 1 - Tie Back Solder Pile Walls

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**Tie back soldier pile walls**

While there are numerous temporary methods available to retain soil for an excavation, the soldier pile wall with tiebacks and wood lagging is the most common. Tie back soldier pile walls are constructed with wide flange steel beams (a.k.a. the soldier piles) usually spaced 5 to 10 feet apart. The walls can be 50 feet in height or greater from the top of existing grade to the bottom of the trench. Tiebacks are installed integrally aligned with the soldier pile. The space in between the soldier piles is constructed with thick wood planks (a.k.a. wood lagging) inserted between flanges of the piles and span from soldier pile to soldier pile to retain the soil. Groundwater cannot be tolerated and must be removed based on requirements set forth in geotechnical and subsurface hydrology reports.

Prior to excavation, soldier piles are usually drilled into the ground for lateral stability to a depth exceeding the bottom of future excavation. Soldier piles can also be driven with a pile driver but it must be determined beforehand if vibrations from pile driving activity could potentially damage adjacent structures.

If the pile is drilled in, construction of the soldier pile tieback wall begins by using an auger to create an oversized hole for the pile. The full length pile is then inserted into the open hole. Piles over 60 feet in length can be mechanically spliced together by welding. Lean concrete (i.e. flowable fill) is installed from the bottom of the pile up to the trench base. Once piles are in place, excavation begins from the top down.

The excavation advances in tiers, with the installation of wood lagging as the excavation progresses. A tier is reached when the excavation approaches a level of the tie backs. From this location, the tieback must be installed before the excavation can advance. During the excavation to the different tiers, the wall will deflect and behave differently as the excavation deepens. The lateral wall movement will cause a downward consolidation of soil (settlement) on the retained earth side of the wall.

Tiebacks are installed at an angle by drilling into the ground on the retained earth side of the wall. The engineer specifies the bonded and unbonded length of the tiebacks. Unbonded length is utilized so the anchor does not restrain the soil in the triangular failure wedge immediately behind the wall as shown in Figure 1 above. The tiebacks are injected with grout and then are tensioned with hydraulic rams to achieve the required design strength. The tiebacks extend into the boundaries beyond the confines of the building property and usually under existing neighboring foundations or roadways. Therefore, permission must be granted by the neighboring property owners and roadway officials since there is the potential of earth movement which could cause damage to an adjoining structure.

A properly designed wall in high quality sands is permitted by industry standards to laterally move between 0.002H and 0.005H where H is the overall height of the wall. Sensitive and historic structures will not tolerate even these minimal movements. Therefore, careful consideration must be given to determine what movement can be tolerated by the adjoining structure on the neighboring property. The proximity of the adjoining structure may require underpinning.

Careful planning and engineering must be implemented by a specialty engineer and contractor well experienced in the design and construction of these specialty systems. Proven design concepts and standards are used to construct the walls. All soldier pile walls are different and must be analyzed on a project to project basis. Of upmost importance are the potentially affected adjacent building structures situated on the retained earth side of the soldier pile wall. As stated previously, soldier pile walls are anticipated to deflect laterally causing downward consolidation (settlement) in the failure wedge shown in Figure 1. If a building is present in the proximity of this failure wedge, the lateral movement will cause the soil to vertically consolidate thus undermining the support of adjacent buildings on the retained earth side. Planning and design must be considered to ensure that damage to the building will not occur or is maintained at some predetermined acceptable minimum level. The result can be irreparable damage such as concrete slab shifting and settling, cracks on foundation walls, shifting of the foundation structures, and/or loss of structural support of framing members.

Figure 2 - Pile Driver in Use

**Construction Vibration**

There are several ways that harmful vibration levels due to construction activities can cause damage to neighboring properties and structures. The most common include; damage to a structure directly from the energy of the vibration source, resonant structure response (i.e. the natural frequency of the

building and soil matches the frequency of the ground movement causing uncontrollable shaking) and/or the densification of soils supporting a building structure resulting in settlement. All these vibrational effects can result in cosmetic damage and/or irreparable structural damage.

Vibration can occur from numerous construction activities, including:

- Blasting
- Pile driving
- Compaction / dynamic compaction
- Jackhammering / chiseling
- Vibrofloatation
- Pavement breakers
- Demolition
- Trenching activities
- Heavy vehicle traffic

If construction activities which include potentially damaging vibration are scheduled to occur on a specific job site, it is imperative that one or all of the suggested measures below be implemented:

- A well-planned due-diligence investigation and project coordination of neighboring properties. An example would be to determine if a neighboring facility has sensitive electronic, instrumentation or imaging equipment such as an MRI that may be disrupted by construction related vibration activities.
- A pre-construction survey of all adjoining structures
- A geotechnical report that clearly identifies the underlying soil strata and geologic conditions
- Specifications for the control of construction vibrations
- Pre-planning to avoid potential vibration damage by selection of alternate construction equipment. For example, auguring/pre-drilling piles as opposed to pile driving.
- Construction logs of equipment and approximate time frames of construction
- Vibration monitoring by a licensed testing agency
- Building movement monitoring of neighboring structures by a licensed testing agency

Prior to construction activity, it can be desirable to establish a benchmark, especially if there is pre-existing damage such as settlement or structural deficiencies to neighboring structures. This particularly

holds true if the building is older and would have a tendency for a lower tolerance of vibration induced damage.

Furthermore, forensic studies following a claimed damage event, to determine if a building was damaged by neighboring construction vibrations, should include knowledge of the geological conditions, where the vibration producing activity took place on the construction site, if there were any monitoring devices, and whether there were pre-construction surveys that could be evaluated as a bench mark for pre-existing damage. Therefore, it is imperative to document the location and type of construction activities which occur relative to the potential damage.

Damage can occur due to direct energy imparted on the building structure such as blasting or consolidation of soils such as settlement. Underlying soils can vary from clays to sands to rock or a combination thereof. Depending on the type of underlying soil, vibration induced by construction activities can result in different types of damage and result in significantly different outcomes as far as building structure damage. Extended exposure to vibration over a period of time can yield more potential for densification resulting in more settlement of the soil.

Direct energy from vibration which can damage structures is a function of the type of construction equipment or method used (i.e blasting), the distance away from the source, along with type of soil present. There are well known resources establishing vibration threshold limits which can cause damage to various building materials such as plaster, concrete, and masonry. Different materials are more brittle than others and thus more susceptible to vibration damage.

VIBRATION & DEEP EXCAVATION DAMAGE INVESTIGATIONS

There are numerous construction activities in an urban setting that can potentially damage neighboring structures. Deep excavation and/or construction related vibrations are primary culprits. Careful planning and engineering, pre-construction surveys, vibration monitoring, neighboring building movement monitoring, project coordination with neighboring properties, and overall due diligence all play a vital role in successful completion of a new foundation system within an urban setting.

In instances where vibration related damages are suspected, the engineers at Robson Forensic can provide a comprehensive investigation to determine causation and evaluate construction means and methods.

Submit an inquiry **to get connected with an expert relevant to your case.**

**FEATURED EXPERTS**

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**Structural Engineer & Construction Expert**

Anthony Volonnino is a structural engineer with over 30 years of experience involving buildings, wood framing, modular structures, bridges, transmission towers, roadway structures, and other structural

systems. He has specialized knowledge in the dynamics of structures, incorporating wind, seismic and vibrational analysis as it relates to structural design requirements and failure analyses. Anthony applies his expertise to forensic casework involving failed buildings, bridges and other structures, construction defect claims, and professional liability disputes.

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